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THE EFFECTS OF MARKET PRACTICES IN OLIGOPOLISTIC MARKETS: AN EXPERIMENTAL EXAMINATION OF THE ETHYL CASE

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ABSTRACT

This study reports on the performance of experimental markets characterized by industrial structure and practices similar to those at issue in the Ethyl case. The central question is whether price competition is affected by the practices of advanced notification of price changes and "most-favored nation" contracts or is determined by industrial organization and concentration alone.

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I. INTRODUCTION

In May of 1979 the Federal Trade Commission (FTC) filed a complaint[1] against the producers of lead-based antiknock compounds, the gasoline additives that raise the octane level. The FTC asked that the four domestic producers in the industry cease and desist from using market practices that, according to FTC theory, facilitated a reduction in price competition in violation of Section 5 of the Federal Trade Commission Act, 15 U.S.C. §45. As part of the general defense, experts claimed that the conduct of the industry could be explained as resulting from industrial structure alone, the practices had no discernible effect, and thus the relief sought by the FTC would be ineffective and should be denied. This study reports on the behavior of laboratory markets characterized by the prominent structural features of the lead-based antiknock compound industry with and without practices similar to some of those at issue in the litigation.

The industry structure is one of the major parameters in all theories applied in the analysis of the case, and there is little or no controversy over its key features. The products, tetraethyl lead, tetramethyl lead, and mixes of these two compounds, are homogeneous across producers. Demand is generally believed to be inelastic in the vicinity of existing prices. Entry was effectively blocked during the period of the complaint (January 1, 1974 to May 31, 1979) because demand was expected to be significantly reduced due to Environmental Protection Agency regulations regarding the phaseout of the use of lead in gasoline. The products are used only as a gasoline additive. There are only four firms in the industry, Ethyl Corporation, E. I. du Pont de Nemours and Company, PPG Industries, Inc., and Nalco Chemical Corporation. The two largest firms apparently possess excess capacity, and the other two firms are relatively small, 12 percent and 18 percent of the market respectively. Ten large buyers out of one hundred and fifty or more account for approximately 60 percent of the market.

Three practices are challenged by the FTC complaint.

A. Advanced Notice and Price Announcements. Suppliers agreed to give at least a thirty-day notice of all price increases. These price announcements were transmitted to customers by telephone and telegram and, in addition, were announced to the press. Price announcements were usually made in advance (three to eight days) of the thirty-day deadline by firms initiating a price change.

B. Most Favored Nation. The two large producers consistently used "most favored nation" clauses in contracts, and the other two suppliers used them in various ways. The central feature of this practice is to guarantee to each customer that no other customer

will obtain a like quantity and quality at a lower price.

C. Delivered Pricing. Delivered pricing is practiced by all four firms. Each firm quotes a list price for a given compound delivered to the purchaser regardless of the location of the producer.

The Commission's administrative law judge summarized the facts as follows:

> The facts relating to the use of the challenged practices by the respondents are not controverted. All respondents use 30-day advance notice of price increases; until mid-1977, all respondents issued press notices or price changes; all respondents utilize delivered pricing, and uniform delivered pricing with respect to all list price transactions. Respondents Ethyl and DuPont utilize most favored nation clauses in their contracts with customers (these respondents did not have contracts with all customers); and Nalco had most favored nation clauses in all its contracts until 1978, and with a few contracts thereafter (this respondent also did not have contracts with all its customers). Use of the practices having been established, it remains to determine the effect of the practices on competition. [U.S. Initial Decision, 1981, p. 135]

The FTC claim is that the practices, combined with the industrial structure, enabled suppliers to maintain prices above competitive levels (Complaint Counsel's Proposed Finding, 1981). The theory is based on the hypothesis that competition is aided by uncertainty about rival firms' actions and/or reactions to pricing decisions. First, the use of delivered pricing policies reduces the dimensions in which price concessions can be made thereby reducing the uncertainty about the terms which competitors have offered to individual customers and the magnitude of price changes. Secondly, the greater the use of the most favored nation clauses by a firm, the

more the tendency for a firm to charge all customers the same price for a given product and give secret price discounts to no one. The delivered pricing policy buttresses this most favored nation practice by making the term, ''price,'' reasonably unambiguous. That is, it helps prevent effective special price discounts which might exist under some other name. The two practices together thus reduce uncertainty about a competitor's actions and, by virtue of the market structure, facilitate the stability of higher prices through a process of conjectural variations.[2] The most favored nation clause can also add stability in another way. Buyers tend to believe that any price concession or discount obtained will automatically be extended to other customers. A discount to a single customer would thus be more costly to the supplier than the production and delivery cost of the marginal product and would thus be less likely to be granted. Knowing this, buyers as individuals (and thus as a group) bargain less tenaciously and are a less important source of potential disruption of price stability. The conclusion is that the first two practices contribute to price stability at whatever price level happens to have been established.

The advance notice provision helps establish the price level. Price increases are usually announced several days before the deadline for an announcement. That is, if a thirty-day advance notice was the policy, then an increase would be announced, say, thirty-seven days prior to the date that the price increase was to take effect. This announcement, made publicly through the newspapers, would be

transmitted to competitors immediately and accurately. Other firms which have a similar thirty-day advance notice policy have seven days in which to respond. If they match the higher price, then all firms have stable prices at the higher level. If any firm does not match the price, then the announced price increase will be rescinded,[3] and the nonmatching firm will gain no volume from its nonconforming behavior. In this strategic environment, each firm has a dominant strategy to match the price increase as long as it anticipates higher profits from joint upward price movements. No firm has an incentive to "chisel" or "undercut" the prices of others. Thus the process of prior announcement provides a dynamic element through which price levels can be established and the practices taken as a group serve to coordinate actions and reduce price competition.[4] A natural theoretical extension of the argument leads to a prediction that prices should equilibrate at the lowest of the optimum industry prices from the individual firm's point of view.

Economic experts (Dennis M. Carlton, Michael L. Glassman, George A. Hay, H. Michael Mann, and Jesse W. Markham) who testified in the case have been in substantial agreement about the facts of the case regarding the economic structure of the industry. The plausibility of the government's theory as it relates to the basic principles of economics was also not a subject of debate. The controversy surfaced in the analysis of industrial conduct and the relative role of the challenged practices in accounting for performance.

Nonprice competition and discounts could be observed. Neither advance notice nor price publication was always followed. Market shares changed. Transportation costs were relatively low. Most favored nation clauses were not in all contracts. Information about competitors' list prices was readily available from customers and there was frequently little time delay between the time a price change was announced and the first time information of the change reached a competitor. Opinions about costs and profits differed. Such facts led to differing evaluations about how much competition actually exists in the industry and what one would expect to see in terms of such variables in an industry with a market structure like that of the lead-based antiknock compound industry.

The Commission's administrative law judge summarized the controversy as follows:

> Respondents' economic experts were unanimous in their opinion that the structure of the industry was the determining factor on the competitive performance of the industry; and that the industry was performing as competitively as would be expected based on the structure. Dr. Hay, complaint counsel's expert, testified that the structural characteristics in conjunction with the challenged practices had reduced the vigor of competition, and that in the absence of the practices, competition would have been more vigorous. [U.S. Initial Decision, 1981, p. 136]

The issue to be explored in this study is the potential effect of practices similar to some of those in the Ethyl litigation over and above that of industrial structure. Can such a set of practices facilitate a reduction in price competition or do supracompetitive prices and profits necessarily constitute an equilibrium within an industry with this structure? The laboratory markets studied below

were designed to answer that question. The practices examined are similar to practices challenged by the FTC complaint, and the industries studied are similar in structure (but much smaller in scale) to the lead-based antiknock compound industry.

2. EXPERIMENTAL DESIGN

A. Procedures

Subjects were recruited from Pasadena City College, the California Institute of Technology, and the Pasadena business community. All subjects had participated in at least one laboratory experimental market prior to participating in the experiments reported here, and many subjects had participated in several such experiments. Previous experimental research had suggested that experience may be an important variable in oligopolistic experimental markets but, aside from that variable, no subject pool differences (age, sex, education, nationality, etc.) have been documented to date.

All experiments were conducted in Baxter Hall at the California Institute of Technology and each lasted between three and four hours. Subjects were randomly assigned to an incentive structure as explained below and to an office. Instructions were read, questions were answered publicly, and subjects completed a ''test'' designed to check their understanding of the rules, incentive structure, etc. The instructions are included as an appendix. The suppliers were given a special sheet not seen by buyers on which the market demand function was graphed and its meaning was explained to them. This is also included as part of the instructions.

Most of the experiments reported here were not conducted according to any plan known to the subjects. This reduced the possibility of overt collusion. The exceptions are experiments 8 through 11 which were held on consecutive nights with the same subjects, but on any given night they did not know the nature of the experiment for the next night. The possibility of collusion external to the experimental setting was also reduced by a policy of changing the demand and supply functions by a scalar so the price units were not readily comparable.

B. Parameters

Lead-based antiknock compounds are added to fuel to increase the octane ratings. The two basic products, tetraethyl lead (''TEL'') and tetramethyl lead (''TML'') are homogeneous products in that no qualitative differences exist among the products sold by different manufacturers. Mixtures of these two basic products are also sold but these do not differ in quality among producers. Other chemical products exist which can increase the octane ratings of gasoline, but these are relatively expensive. Octane ratings can also be increased by additional processing (catalytic reforming) but it is also more costly. Thus, the commodities are homogeneous with no substitutes in the price ranges under consideration.

The product homogeneity was incorporated in the laboratory markets but only a single commodity existed in the laboratory markets rather than the two basic commodities and the mixes. Individual demands for a single, homogeneous commodity were induced, by

application of induced preference theory,[5] in the following manner. Buyers made money by purchasing from sellers and reselling to the experimenter. The terms of resale dictated the individual demand elasticities and volume demands. Likewise, sellers made money by buying from the experimenters and reselling to the buyers. The cost schedule faced by individual sellers dictated their capacity, marginal costs, and other aspects of variable costs. It was unnecessary for sellers to carry inventory of the product because they could, up to capacity limits, produce instantly to satisfy demands, and they would only incur the variable cost associated with production.

The market demand and supply functions are displayed in Figure 1. The actual shape of the demand function is approximately the right half of an inverted parabola with the equation

$$p = 1.81 - Q^2/256.$$

With this equation and the supply function as shown, the competitive equilibrium is $.54 per unit. Demand elasticity is .218 in the range of the competitive equilibrium. The second-order curve was chosen rather than a linear curve because the responsiveness of demand to price in these price ranges is likely to depend primarily upon substitutes rather than the effect on gasoline price and gasoline demand in the retail market. Substitutes are likely to become available in volume once they become economically feasible relative to lead-based compounds. This accounts for the substantially reduced demand at the higher prices. Demand in the experimental market in the

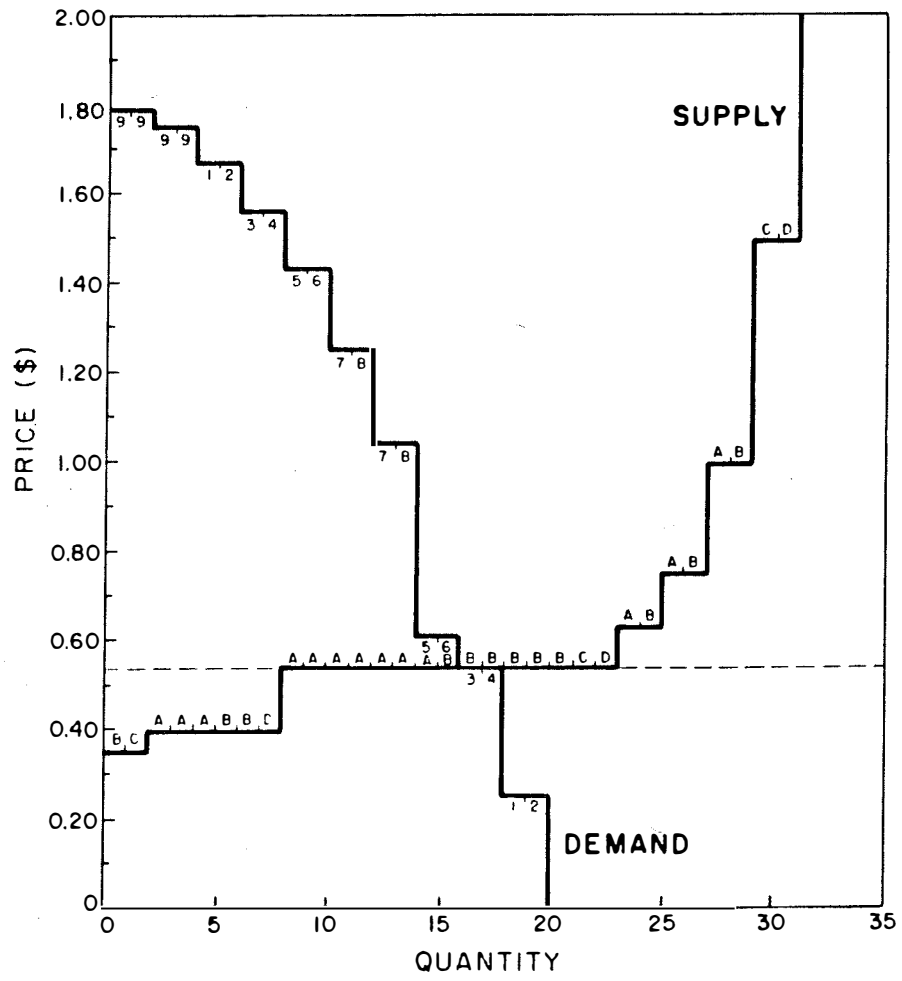


FIGURE 1

range of the competitive equilibrium is probably more inelastic than is the demand for lead-based antiknock compounds at current price levels. However, as price increases, elasticity increases; for example, elasticity is .69 at $1.05 and it is 1.10 at $1.25. By multiplying the units in the experiment by a factor of two million and considering the time period to be two weeks, each unit would represent two million pounds, and its value would be two million times the price. Naturally such scalar transforms preserve all of the relevant economic parameters.

In total, there were nine buyers in the experiment. The market demand function shown in the figure is the aggregation of the individual demand functions, but the individual functions can be inferred as follows. Index the buyers as 1 through 9, and let the numbers under the demand function represent the buyer who had a unit with a limit price at that value. The demand function (or limit price function) of buyer 5, for example, had one unit at $1.43 and a second at $.61. At industrial scale this represents a buyer who would have annual purchases of 104 million pounds if the price was as low as $.54. As can be seen from the figure, buyers 1 through 8 are all about the same size, and these eight buyers are all about equally sized and constitute about 70 percent of the market, depending upon the price level. Buyer 9 is a passive buyer representing a large number of small consumers and about 30 percent of the market. This buyer, who was physically located in the control room with experimenters so some monitoring was possible, simply called suppliers

at random (unless one had a lower price, then he would call the lowest priced seller) and purchase a single unit at the quoted price without negotiating,[6] haggling, or making promises about the future. These statistics are to be compared with those of the industry in which the eight largest buyers account for about 50 or 55 percent of all sales and the largest twelve account for from 60 percent to 70 percent.

Market supply as shown in the figure is flat at approximately $.54 with substantial excess capacity at that price. At the competitive equilibrium of $.54, the laboratory market would be at 78 percent of capacity and at a slightly higher price (e.g., $.65) the industry would be at only 56 percent of capacity. Marginal costs increase rapidly as the capacity limits are reached but, as shown in the figure, some capacity still becomes available at price levels of $1.50.

The sellers are indexed A, B, C, D.[7] Both A and B are large sellers with similar cost and capacity structures. The firm marginal cost curve can be deduced from the supply curve. The letter over the supply curve indicates which firm can supply a unit at that marginal cost. Thus firm A can supply three units at $.40, seven additional units at $.54, and an additional unit at each of $.63, $.75, and $1.00.

As can be seen from the individual costs, the two large sellers have about 82 percent of the total capacity. At industrial scale this would translate into a capacity of 988 million pounds per year for the two large suppliers at the low competitive price and

about 208 million pounds capacity for the two small suppliers. If the price doubled, total capacity would be increased by 29 percent and all of this would be from the two big suppliers. At a price of $.65 the two large suppliers would have an excess capacity of 572 million pounds per year. These parameters are all within the ranges estimated by experts.[8] The concentration on the supply side of the markets we study is slightly higher than that of the industry.[9] Presumably, this biases the results against the FTC case.

The number of sellers was fixed at four for the duration of the experiment. Neither entry nor plant expansion was possible beyond that implicit in the supply curves. This aspect reflects the generally accepted proposition that the anticipated decline of demand for lead-based antiknock compounds would prevent entry.

C. Practices

Communication took two forms. The primary form was by telephone, and the second form was by a digital display device which was used to announce prices. Buyers (sellers) had phone numbers for sellers (buyers) but not other buyers (sellers). During a period they were free to call each other for contracts but no phone conversations were allowed between periods.

The digital display device was designed for price announcements. The device as shown in Figure 2 consisted of four modules. Each module had a push-button keypad, much like that of a hand-held calculator, and thirteen digital receiver units, each capable of displaying a three-digit number and thirteen receiver

panels. Thus, if a seller entered a number on the keypad, this number would be displayed simultaneously on all thirteen receiver units connected with the keypad; e.g., the number 123 would be so displayed, or the number 3 would appear as 003. The largest number which could be transmitted was 999. A receiver unit from each of the four keypads was mounted on each of the thirteen receiver panels. The device had no capability for communicating selectively with receivers. Any number entered was necessarily displayed to all receiver panels, but it was possible for the experimenter to cover the receiver unit within a panel so that only messages sent from selected keyboards were displayed. This allowed the possibility for a seller to have a receiver panel and see the price (s)he displayed but not, for example, the prices of other sellers.

In total, the device consisted of four keypads each of which could communicate with thirteen receivers. This allowed each buyer four receivers, each carrying the number entered from one of the keypads. If, for example, each of four sellers had a keypad, each could enter a price which would be seen by everyone who had a receiver unit attached to that keypad; e.g., the seller, other sellers, all buyers, and the experimenter. By altering who had access to the sending and receiving units and the rules of communicating, practices similar to those of the Ethyl case could be implemented and studied.

Before providing an interpretation of the laboratory markets in terms of industry practices, the laboratory markets themselves will be explained. The market practices in each experiment can be

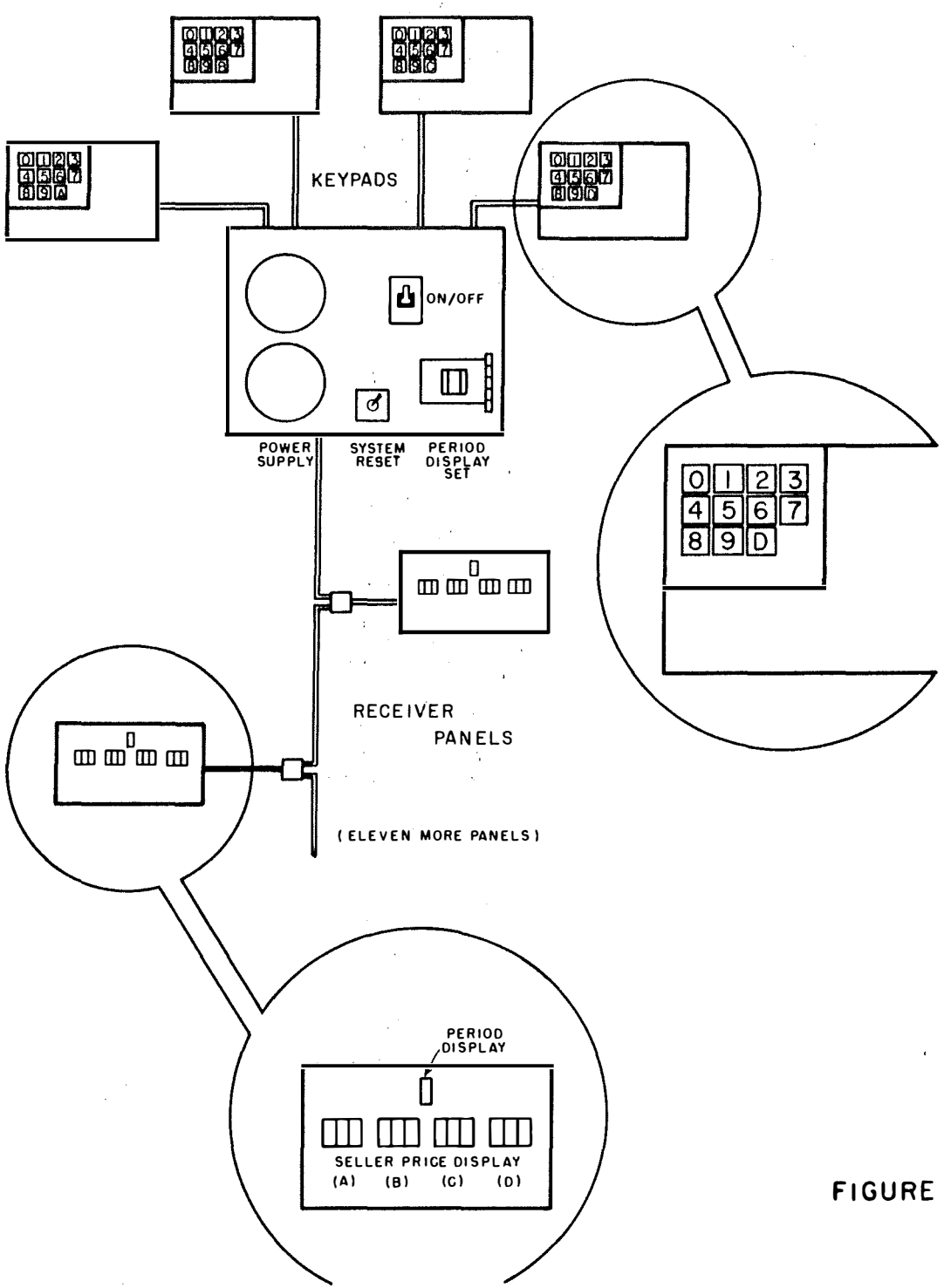

KEYPADS
ON/OFF
POWER SUPPLY
SYSTEM RESET
PERIOD DISPLAY SET
RECEIVER PANELS
(ELEVEN MORE PANELS)
PERIOD DISPLAY
SELLER PRICE DISPLAY
(A) (B) (C) (D)

FIGURE 2

characterized by four different variables, so the practices are indexed by a four-tuple. The first component denotes the agents who were allowed to make the price announcements explained below. The letters N, A, L, which constitute the range of the first variable, represent: N = no price announcements; A = all sellers make price announcements; L = large sellers make price announcements. The second component, which denotes those who were able to receive the price announcements, takes the two values as follows: A = all participants receive the price announcements; B = only the buyers and not the sellers receive the announcements. The third variable takes the value Y if a most favored nation practice was uniformly imposed on sellers making price announcements, and it takes the value N if not. If N is in the third place, then firms can discount from announced prices. The fourth and final variable takes the value Y if prior notification is required for price increases, and it takes the value N if not. Thus, the notation (A,B,Y,Y) means that all firms had policy price announcements which were received only by buyers (and not sellers); all firms used most favored nation clauses and prior notification of price increases.

We did not examine either delivered price policies or press release policies. This reflects limitations placed on the experiments by previous experimental work in the field and by current experimental technology. The inclusion of transportation costs, mixing, and other complications which would expand the single homogeneous commodity to one with several dimensions (e.g., the commodity plus transportation

services) and make it more consonant to the industry in which the delivered price policy is operative would have also placed a substantial burden on the study. Computations would be more complex for participants so additional time would be necessary for conducting the experiments. Few experiments have been conducted with multiple commodities so the laboratory procedures for new experiments would not have the advantage of having been ''distilled'' by considerable previous use in laboratory studies. More complex situations can be accompanied by more mistakes and other sources of randomness so the number of experiments required would be increased if multiple commodities were used. Literally speaking, since transportation costs were always zero in these experiments, the delivered pricing policy is always in effect.

The primary focus of the study is on only two treatment conditions, the case where there are no practices and the case where all practices are used by the two largest sellers. In the course of the experiments, however, the opportunity to obtain a preliminary examination of some of the variations in the practices presented itself. The seven treatment variables on which some data were gathered are listed below, and are ordered according to the degree to which all of the practices were present. Thus the list begins with the case in which there are no practices and ends with the case in which all practices considered were operating by all firms.

Privately negotiated prices (N,-,N,N). In this market, contract prices were privately negotiated by telephone. Each supplier was free

within the constraints set by costs to follow whatever pricing policy desired, but the device was not available for price announcements. There was no expectation that a most favored nation clause would be enforced. Suppliers necessarily relied on customers as the sole source of information about the pricing policies and price levels of competitors.

Nonpublic price lists (A,B,N,N). This practice was implemented by use of the display device. Each supplier was given a keypad, but the prices were displayed to the buyers only. Each supplier had a receiver panel so his/her own price announcements could be monitored, but the receiver units of other suppliers were blocked out so their transmissions could not be seen. Discounts from announced prices were allowed so the most favored nation practices were not operative. The ''bait and switch tactics'' of advertising a low price but refusing to sell at that price were not permitted.

Nonpublic price announcements with most favored nation (A,B,Y,N). As above, each supplier was given a keypad and all prices were displayed to buyers only. With the most favored nation clause no discounting from the announced price was allowed. Thus, all buyers paid the same price during a period when the same price was being announced. A seller could lower the price to make a sale but all orders made while the price was lowered were necessarily filled at that price. Because price announcements were nonpublic, sellers could become informed about a competitor's price only if informed by a buyer or buyers.

Public price announcements (L,A,N,N). Both large sellers[10] had keypads, and all participants, both sellers and buyers, had receiver units. Thus, price announcements by large sellers were immediately seen by all participants. Discounts from these announced prices were possible and were privately negotiated. All prices of the two small sellers were privately negotiated. This is similar to a case in which list prices are publicly available, costlessly changed, and may differ from actual transaction prices.

Public price announcements and most favored nations (A,A,Y,N). All sellers had keypads and all participants had receiver units, so price announcements were seen by all participants. All contracts were executed at the announced prices. These practices have elements of the delivered price policy since prices could easily and unambiguously be communicated and understood. In this context the most favored nation clause, which prohibits secret discounts acts in many respects identically to that used in the lead-based antiknock compound industry. If nonprice competition and services are ignored, the clause guarantees the same price to those who purchase like quantity and quality.

All practices (L,A,Y,Y) and (A,A,Y,Y). Sellers (either the two large sellers only in some cases and all sellers in other cases) made public price announcements. All transactions took place at announced prices. Price increases were allowed only after one full period of advance notification. This was accomplished with the aid of a second keypad

in (L,A,Y,Y)[11] and by a special signal in (A,A,Y,Y). For example, if a large seller desired to increase price in period 8, this was announced to all participants prior to the beginning of period 7. Price decreases could be made at any time, but once price was reduced, it could not be raised without the proper notification. In this treatment, volume data for all suppliers was also made available at the end of each period, thereby reflecting a situation in which information is reasonably accurate.

Of primary interest are the cases (N-NN) and (LAYY). The treatment (N-NN) seems to be the most analogous to the situation which is supposed to exist if the remedy sought by the FTC is successfully implemented. The treatment (LAYY) is most analogous to the situation which now exists.

Two treatments (ABNN) and (AAYY) are of little interest and were included only as checks. On a priori grounds one would expect market behavior under treatment (ABNN) to be approximately the same as (N-NN). If competitors cannot directly monitor price announcements and if the announced prices themselves are subject to discount, one would expect very little difference from no announcements at all. Advertising might have an effect on buyer behavior to the extent that search costs are important and to the extent that advertised prices reflected actual prices. Aside from this effect, which is expected to be small in these markets, one would expect (ABNN) and (N-NN) to be the same. Similarly, (AAYY) should be the same as (LAYY). The volume of the two small sellers is so low that they should adjust to the

pricing policies of the larger sellers. Thus, as is implicit in the models outlined in the next section (LAYY) and (AAYY) should exhibit approximately the same behavior. Only one experiment with (AAYY) was conducted as a check.

The other three treatments are of independent interest. The treatments (ABYN) and (AAYN) are similar to circumstances which could evolve from Robinson-Patman provisions. All buyers pay the same list prices which are known costlessly to buyers. Under (AAYN) sellers have access to the same pricing information as buyers, whereas under (ABYN) sellers do not. The treatment (LANN) provides some insight into the pure effect of public price announcements.

3. COMPETING MODELS

Two different questions are identified. (1) Do the practices make a difference? (2) What models most accurately capture experiences with the behavior of markets with the structure described above? The first question is a purely statistical question once the experimental design has been set. The second question is more complicated because of the existence of a rich and varied set of models which differ according to the role of time, product differentiation, the nature of the strategy spaces, etc. The models explored here are all static and are based on the hypothesis that the product is perfectly homogeneous across sellers.

The models can most easily be explained by reference to cases in which all functions are differentiable. The numbers listed as predictions, however, are derived from the discrete analogs. The

individual large seller, i, has an incentive to satisfy the equation

$$P(x_1 + x_2 + 2k) + x_i \frac{\partial P(x_1 + x_2 + 2k)}{\partial x_i}(1 + \frac{\partial x_j}{\partial x_i}) - \frac{\partial C(x_i)}{\partial x_i} = 0$$

where x_i is the volume of seller i; $P(x_1 + x_2 + 2k)$ is the inverse market demand function; k is the constant volume of a smaller seller constrained by capacity; $C(x_i)$ is the cost function of seller i. The equation simply reflects optimizing behavior and the assumption that small sellers behave in a price follower role and are aggressive only to the extent necessary to sell a volume of k.

The term $\partial x_j/\partial x_i$ is the reaction by firm j as anticipated by firm i to a change in the volume of firm i. A continuum of models can be derived from this formulation by letting $\partial x_j/\partial x_i$ range from -1 to 1 (see Telser 1972 p. 152-53). The term is in a sense a measure of perceived interrelatedness and indicates that competition goes down as such awareness goes up. For purposes of analysis we arbitrarily restrict the class of admissible models to only four.

Competitive Equilibrium and the Bertrand Model. If $\partial x_j/\partial x_i = -1$, the behavioral equation above becomes P = MC. The competitive interpretation is that sellers view their actions as having no perceptible influence on price because any volume increases will be offset by volume decreases elsewhere. The Bertrand oligopoly interpretation is that the firm believes customers can be stolen from a competitor by slight price reductions and such reductions will be met only passively if at all.

If the market shares between the two large sellers are equal or near equal, this equation is satisfied at \$.54. Thus both the competitive equilibrium model and the Bertrand model predict \$.54. The volume prediction is eighteen units per period.

Cournot Equilibrium. If $\partial x_j/\partial x_i = 0$, each seller is assuming that price reductions will be met with sufficient speed to protect sales volume measured in physical units. If quantities rather than prices are viewed as the control variables, then according to this model each seller plays a best reply strategy against the quantities offered by the other seller. The equilibrium is thus Nash. If volumes are near equal, the price which supports the Cournot equilibrium is \$1.04. The volume prediction is fourteen units.

Price Leadership Joint Maximum. Each of the two large firms may believe that price cuts will stimulate further price cuts. If it is believed the competitive reaction will be sufficiently vigorous to protect existing volume and also share in new market volume created by lowered prices, then $\partial x_j/\partial x_i > 0$. A joint maximum occurs if $\partial x_j/\partial x_i < 1$. With this assumption a quick derivation will demonstrate that the price result is the same as if the two large firms combined to form a price-leading dominant firm. Of course a combination would possibly resort to some enforcement mechanism other than the conjectural variation. The price prediction of the model is \$1.25, and the total volume prediction is twelve units per period. At this price, because of the cost symmetry, a near equal split occurs if the

volumes are the same.

Global Joint Maximum. If all sellers maximized total joint profits, the price would be $1.42, and volume would be ten units per period. Since there are no side payments and no conspiracies, many scholars would not expect the joint global maximum to occur.

Models of this sort while commonly used are obviously incomplete. No hint is provided about which model might apply for any given treatment variable. The controversy generated by the Ethyl case adds a new dimension and justifies the formation of three hypotheses. One is that the treatments have no effect at all and thus the same model should apply across all treatments. An alternative taken from the FTC arguments is that the treatments have an effect on prices and that prices under treatment (LAYY) will equilibrate near the price leadership joint maximum and (N-NN) yield prices below that. A third is that prices under treatments which incorporate only some of the practices should lie in between those of (LAYY) and (N-NN).

4. EXPERIMENTS

Eleven experiments were conducted under several different configurations of the practices as shown in Table 1.[12] In all cases the economic parameters are identical and constant for the duration of the experiment. In most cases a change in practices occurred during the course of the experiment so that the effect of a change in practices could be studied. Thus experiment 3, for example, had the first eleven periods under the (N-NN) conditions of no practices at

all. All of the practices were imposed on only the large sellers for periods 12 through 15 and then all practices were removed for periods 16 and 17.

5. RESULTS

The average transaction prices for all periods of all experiments are graphed in Figure 3. The graphs also contain a reference to the practices which were in force when the transactions occurred. For example, in the first eleven periods of experiment 3 which operated without the practices, average price can be seen converging toward the competitive equilibrium. Imposition of the practices during period 12 is accompanied by an immediate average price jump. When the practices are removed in period 15, the average price immediately falls.

It is apparent from Figure 3 that there is a substantial correlation between prices in consecutive periods. Thus, in assessing statistically the effects on transaction prices of the different market institutions, one cannot simply combine all observations into a single data set and use ordinary least squares regression analysis. We considered estimation of a variety of dynamic models with autocorrelated error structures, but decided against pursuing such an approach for two reasons. First, it is not clear that generally accepted theoretical models of the dynamic adjustment of these types of markets exist. Thus there would be an essential ad hoc element to any particular model employed. Second, and most important, we did not wish to deflect attention away from the basic issue, viz., did the

TABLE 1

PERIODS OF EXPERIMENTS IN WHICH VARIOUS PRACTICES WERE OPERATIVE

Group	Price Publication {N,A,L}*	Receiver Units Holders {A,B}**	Most Favored Nation {Y,N}***	Advance Notification {Y,N}***	Experiment Number										
					1	2	3	4	5	6	7	8	9	10	11
I	N	-	N	N	1-20	1-20	1-11 16-17	1-4					1-8		
	A	B	N	N				16-18		1-11	20-23				
II	A	B	Y	N					1-10			1-15			
III	L	A	N	N										22-25	10-16
IV	A	A	Y	N					11-16				18-20	1-9	
V	L	A	Y	Y			12-15			12-18	1-19	16-23	9-17	10-21	1-9 17-18
	A	A	Y	Y				5-15							

*N = no seller published; A = all sellers published; L = only large sellers published.
**A = all participants see price publication; B = only buyers see price publication.
***Y = yes, the provision is operative; N = no, it is not operative.

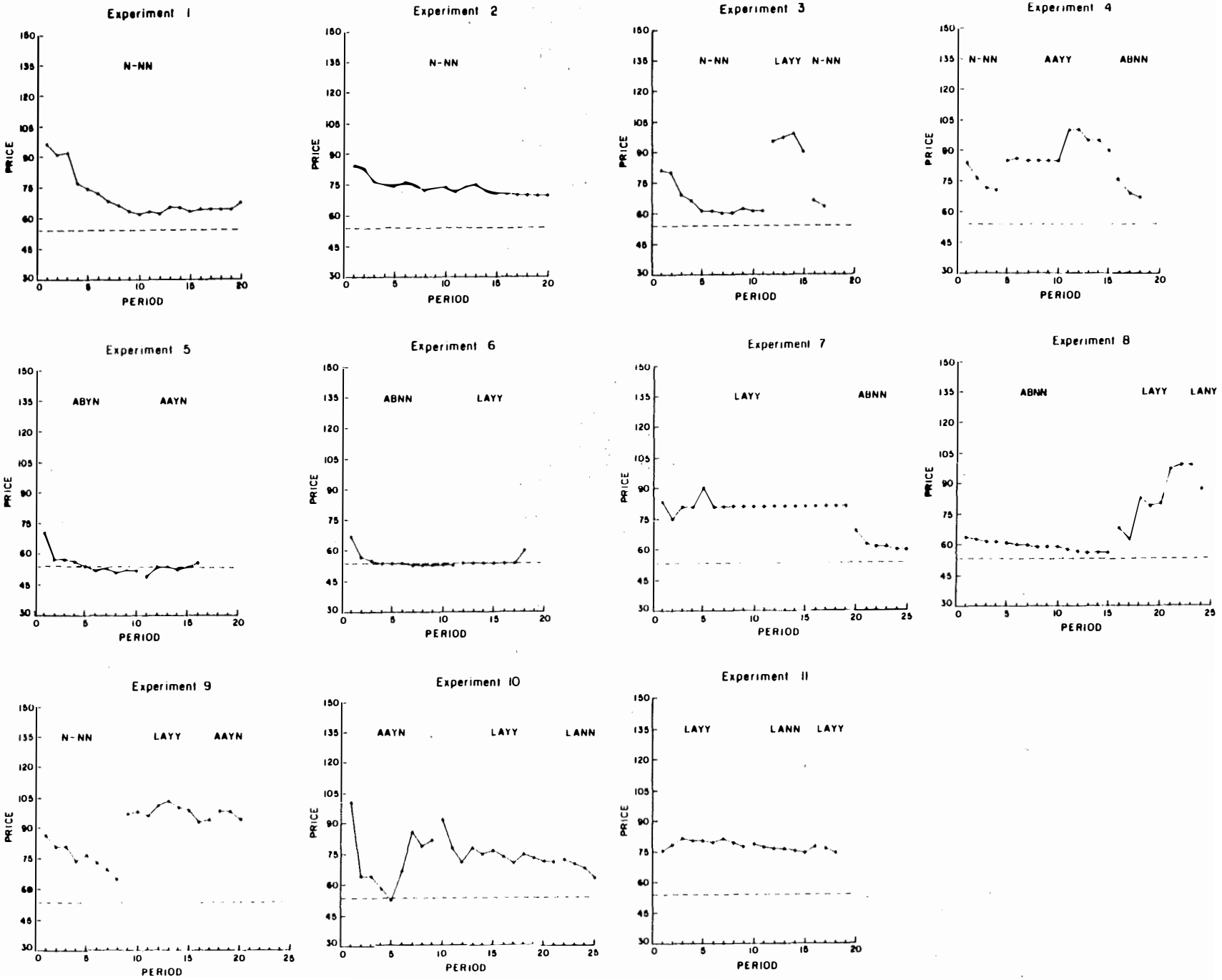

Experiment 1
N-NN
Experiment 2
N-NN
Experiment 3
N-NN
LAYY
N-NN
Experiment 4
N-NN
AAYY
ABNN
Experiment 5
ABYN
AAYN
Experiment 6
ABNN
LAYY
Experiment 7
LAYY
ABNN
Experiment 8
ABNN
LAYY
LANY
Experiment 9
N-NN
LAYY
AAYN
Experiment 10
AAYN
LAYY
LANN
Experiment 11
LAYY
LANN
LAYY
PRICE
PERIOD

FIGURE 3

different institutional arrangements affect prices in a systematic and economically (as well as statistically) significant fashion? The statistical analysis performed was quite simple: rather than pooling observations sequentially within a given experimental setting, we combined observations at corresponding points across treatments and experiments. For example, one data set consists of all first periods of each treatment; another of all second periods; etc. This procedure should remove any serial dependence but, of course, does so at the cost of a substantial reduction in sample size.

The seven treatment variables listed in section 2-C above were incorporated as binary variables in an analysis of variance, and the results are reported in Table 2.[13] Each coefficient shown is the average price over all experiments for the indicated period of the treatment. For example, the average of first periods prices for treatment (ABYN) is $.68, and the average of first periods prices for treatment (AAYY) is $.85. The average of last periods prices (for treatments longer than four periods) is lowest for (ABYN) at $.52 and is highest for (AAYY) at $.90. The results for several periods are shown, thus indicating the behavior of prices over time for different treatments. The results of combining the seven categories into five categories that are a priori equivalent as discussed above are also included.

The analysis of price data is contained in three different subsections below, and an analysis of volume and efficiency follows those. The first subsection examines the influence of the practices

taken as a group. The second subsection explores the relative accuracy of the models listed in section 3. The third subsection contains a limited analysis of the individual practices. Unless otherwise stated all results will refer to the final period average prices of treatments lasting at least five consecutive periods. The tables summarizing the results provide data for other periods also but for the sake of brevity we shall not discuss them in detail.

A. Results: Practices as a Group

One issue raised by the Ethyl case is whether or not the practices taken as a set have an effect independent of the market structure. The following conclusion states this proposition formally.

Conclusion 1. Average price under treatment (LAYY) is higher than average price under treatment (N-NN).

In the markets examined by this study the conclusion is supported. A one-sided t-test of the hypothesis that prices under (LAYY) are equal to those under (N-NN) is rejected at the .05 level of significance ($t = 2.0$). The alternative hypothesis is that prices under (LAYY) are higher.

As argued earlier we expected little difference between (AAYY) and (LAYY). Furthermore, since prices under (LAYY) and (AAYY) are not significantly different from each other ($t = 0.8$) it seems reasonable to ask if prices in (N-NN) are less than prices under (LAYY) and (AAYY), and the answer is yes ($t = 2.3$) at the .025 level. We also argued a priori that (ABNN) was similar to (N-NN). From Tables 2 and

TABLE 2

		First Period (n = 26)		Second Period (n = 25)		Third Period (n = 23)		Fourth Period (n = 21)		Fifth Period (n = 18)		Sixth Period (n = 18)		Seventh Period (n = 17)		Eighth Period (n = 15)		Last Periods* (n = 18)	
		Estimated Coefficient	Standard Error	Estimated Coefficient	Standard Error	Estimated Coefficient	Standard Error	Estimated Coefficient	Standard Error	Estimated Coefficient	Standard Error	Estimated Coefficient	Standard Error	Estimated Coefficient	Standard Error	Estimated Coefficient	Standard Error	Estimated Coefficient	Standard Error
I	N-NN	83	5.8	79	5.4	78	5.8	73	4.5	72	5.9	71	6.0	68	5.8	66	4.3	66	5.7
	ABNN	69	8.3	65	7.6	64	7.5	61	7.1	61	8.3	60	8.5	60	11.6	59	8.7	58	8.1
II	ABYN	69	10.1	57	9.3	56	9.1	55	7.1	53	8.3	53	8.5	58	6.9	54	5.0	52	8.1
III	LANN	79	8.3	74	9.3	72	9.1	69	7.1	75	11.8	75	12.0	77	11.6	-	-	77	11.4
IV	AAYN	82	8.3	72	7.6	71	7.5	55	7.1	53	8.3	63	8.5	86	11.6	68	8.7	69	8.1
V	LAYY	80	5.1	77	5.4	81	4.9	81	3.8	79	4.8	82	4.9	82	4.7	85	3.9	80	4.7
	AAYY	85	14.3	86	13.2	85	12.9	85	10.0	85	11.8	85	12.0	100	11.6	100	8.7	90	11.4
Standard Error Regression		14.3		13.2		12.9		10.0		11.8		12.0		11.6		8.7		11.4	
R^2		.15		.28		.38		.59		.57		.54		.64		.83		.59	
$\bar{R}^2$		-.12		.04		.14		.42		.34		.29		.42		.70		.37	
	I	78	4.8	75	4.5	73	4.6	70	3.8	68	4.7	67	4.7	67	5.3	65	4.1	63	4.5
	II	69	10.1	57	9.6	56	9.3	55	7.1	53	8.1	53	8.2	58	6.8	54	5.3	52	7.8
	III	79	8.2	73	9.6	72	9.3	69	7.1	75	11.5	75	11.6	77	11.8	-	-	77	11.1
	IV	82	8.2	72	7.8	71	7.6	55	7.1	53	8.1	63	8.2	86	11.8	68	9.1	69	7.8
	V	81	4.8	78	4.5	82	4.6	81	3.5	80	4.3	82	4.4	85	4.5	87	3.7	82	4.2
Standard Error Regression		14.3		13.5		13.1		10.0		11.5		11.6		11.8		9.1		11.1	
R^2		.06		.16		.28		.53		.52		.49		.54		.77		.55	
$\bar{R}^2$		-.12		.00		.12		.42		.37		.34		.38		.68		.41	

*Of treatments at least five periods long.

3 it is apparent that if one groups (ABNN) with (N-NN), the resulting prices are significantly lower than they are in (AAYY) and (LAYY) ($t = 3.0$) at significance levels of .005. Note from Table 3 that none of the pooling would be objectionable on statistical grounds, i.e., the F-statistics are not close to being significant.

The average prices under (LAYY) vary a good deal from experiment to experiment, while those obtained with (N-NN) appear to be less variable. Using F-statistics to test the equality of the variances (for single periods) leads to rejection of the null hypothesis (level of significance .01) in some periods but not for others. In order to ensure that our reported results were not sensitive to the assumptions underlying the F- and t-statistics, we computed the Wilcoxin rank sum statistic (Lehmann 1975, ch. 1) for the fourth, eighth, tenth, and final periods (of regimes at least five periods long). Generally the results are the same as those reported in the preceding paragraph. Prices under (LAYY) are significantly higher than those used under (N-NN), and grouping the various treatments simply increases the significance levels. Table 4 gives significance levels at which you would reject the null hypothesis in favor of the hypothesis that prices under (N-NN) are lower.[14]

The differences between the first two columns are an indication of greater price variability earlier in regimes compared to later. For instance, the period 4 prices for (N-NN) and (LAYY) are:

N-NN					LAYY					
66	71	74	76	77	54	74	78	80	81	101

while the corresponding data for the eighth period are

N-NN				LAYY				
60	65	66	73	75	79	81	93	99

The drop in the significance levels between the eighth and tenth periods is due to a reduction in sample size (by one N-NN and three LAYY). The final column reflects combining the ending periods from short regimes and longer ones and is as expected intermediate between the period four and period eight results.

We conclude that the practices together operate to decrease price competition beyond that which can be attributed to structure alone. This conclusion holds when comparing (N-NN) against (LAYY), and continues to hold where one groups the treatment a priori close to (N-NN) and compares the prices with those in (AAYY) and (LAYY). In fact the only effect of the grouping is to increase the level of significance, but the qualitative conclusion is the same throughout, viz., as a group practices matter.

B. Results: Model Accuracy.

Which of the competing models most accurately capture the behavior of prices? Figures for the analysis of this question are given in Table 2 and Table 5. Prices with none of the practices (average of last periods was \$.66) tend to be above the competitive equilibrium (\$.54) with the difference significant at the .05 level (one-tailed test) and are far below the Cournot or joint maximum equilibria. Thus conclusion 2 follows.

TABLE 3

STATISTICS FOR HYPOTHESIS TESTING

Results	Analysis Type								
	First Periods	Second Periods	Third Periods	Fourth Periods	Fifth Periods	Sixth Periods	Seventh Periods	Eighth Periods	Last Periods
F(7 to 5)	F(2,19) = 0.966	F(2,18) = 1.461	F(2,16) = 1.216	F(2,14) = 1.001	F(2,19) = 0.709	F(2,18) = 0.553	F(2,16) = 1.218	F(2,14) = 1.541	F(2,11) = 0.613
F(5 to 3)	F(2,21) = 0.438	F(2,20) = 1.311	F(2,18) = 1.316	F(2,16) = 2.639	F(2,21) = 2.357	F(2,20) = 1.482	F(2,18) = 0.683	F(2,16) = 1.345	F(2,13) = 0.934
t(Y vs N)	t = 0.330	t = 0.558	t = 1.394	t = 2.235	t = 1.898	t = 2.286	t = 2.623	t = 4.113	t = 3.011
(5 Classes)	DF = 21	DF = 20	DF = 18	DF = 16	DF = 13	DF = 13	DF = 12	DF = 10	DF = 13
	n = 26	n = 25	n = 23	n = 21	n = 18	n = 18	n = 17	n = 15	n = 18

TABLE 4

RESULTS OF RANK SUM TESTS

SIGNIFICANCE LEVELS AT WHICH NULL HYPOTHESIS

(NO TREATMENT EFFECT) IS REJECTED

	Period 4	Period 8	Period 10	Last Period (at least five)
N-NN vs LAYY	.12	.008	.20	.06
N-NN vs LAYY - AAYY	.07	.005	.10	.04
ABNN - N-NN vs LAYY - AAYY	.01	.001	.04	.006
ABYN - ABNN - N-NN vs LAYY - AAYY	.01	.001	.02	.003

TABLE 5

t-RATIOS AND SUM OF SQUARED RESIDUALS

FOR ALTERNATIVE MODELS

		Competitive (54)	Cournot (104)	Leader's Joint Maximum (125)
N-NN	t	2.055*	6.691***	10.364***
	SSR	1990.18	7291.00	15480.60
LAYY	t	5.641*	5.070*	9.569*
	SSR	5598.17	4798.60	13408.89
AAYY	t	3.149*	1.224	3.061*
	SSR	2734.47	1633.94	2663.03

Degrees of freedom = 11

$*t_{.05} = 1.796$

$***t_{.01} = 2.718$

Conclusion 2. Prices under treatment (N-NN) are above the competitive equilibrium.

From the sum of squared residuals one can see that the likelihood ratio favors the competitive equilibrium model over the Cournot or any of the other models. On this criterion, conclusion 3 is accepted. This conclusion is not sensitive to pooling (ABNN) with (N-NN).

Conclusion 3. Prices under treatment (N-NN) are closer to the predictions of the competitive equilibrium than to the predictions of the other models.

Average price under (LAYY) is $.80 almost midway between the competitive equilibrium and the Cournot prediction and approximately five standard deviations away from each. Statistical tests lead to the rejection of a hypothesis that the data were generated from either model at conventional significance levels. Of course, the likelihood ratio favors the Cournot equilibrium over the competitive equilibrium (slightly) or the predictions of any other of the listed models. Thus, by that criterion, strictly applied, the Cournot model wins. Prices from treatment (AAYY) are higher ($.90) and are not significantly different from Cournot at conventional levels ($t = 1.2$) and they are significantly different from the predictions of other models. This provides a bit more support for the Cournot model. However, when (LAYY) and (AAYY) are pooled, the mean price is closer to the Cournot than under (LAYY) alone but the reduction in variance

does not appreciably influence significance levels obtained with LAYY alone. Thus, we have Conclusion 4.

Conclusion 4. Prices generated in markets with all the practices are almost equidistant from the competitive equilibrium and the Cournot equilibrium.

With respect to the questions initially posed we can supply the following answers. First the prices in markets without any of the practices are above the competitive equilibrium. Thus some support is generated for the idea that market structure alone will foster noncompetitive results.[15] Secondly, the practices as a set cause significantly higher prices. Of the models considered the most appropriate models are competitive without the practices and either the competitive or the Cournot with the practices (slight advantage to Cournot). The joint maximum models can both be rejected in favor ot these.

The fact that the joint maximum models can be rejected is important because a reasonable extension of the FTC theory of the Ethyl case leads to a type of leadership joint maximum prediction and can thereby be rejected as well. This result leaves us without a complete theory of the influence of the practices. It could be argued that prices near the Cournot equilibrium constitute a ''local equilibrium'' in a process which would ultimately terminate at the joint maximum had it not gotten ''stuck.'' The ''lumpiness'' of the units induces a type of discontinuity near the Cournot equilibrium which

might be hard to pass through.[16] This leads naturally to the conjecture that ''smoother'' demand functions would yield the leadership joint maximum. Certainly this conjecture can be checked with additional experimentation.

C. Analysis of Individual Practices.

This study was not designed to explore the possible effects of each practice independently. Only seven of the twenty possible treatment variables were implemented. However, early in the study it became clear that it would be possible to gather some data on the issue of the effects of individual practices without compromising the major goal of studying the practices as a group. In this section the data are analyzed even though none of these paired comparisons relationships discussed here are statistically significant. The conclusions of this section should be regarded as conjectures about what additional experiments will yield based on the available information.

Table 6 contains the results of all t-tests on binary comparisons of variables. Of course these can also be calculated from the analysis of various parameters in Table 2, but they are included here for convenience.

Let P_K be the average of last periods prices under treatment K. If one accepts the a priori assumption that $[P_{AANN} \geq P_{LANN}]$ then the following inequalities exist in Table 6.

(1) $P_{LANN} > P_{N-NN} > P_{ABNN}$

TABLE 6

PAIRWISE T-RATIOS

	N-NN	ABNN	ABYN	LANN	AAYN	LAYY	AAYY
N-NN		0.783	1.389	0.880	0.328	1.976*	1.897*
ABNN	0.783		0.525	1.357	0.962	2.392	2.285
ABYN	1.389	0.525		1.214	1.487	3.035	2.714
LANN	0.880	1.357	1.214		0.571	0.270	0.804
AAYN	0.328	0.962	1.487	0.571		1.214	1.500
LAYY	1.976	2.392**	3.035***	0.270	1.214		0.783
AAYY	1.897	2.285**	2.714**	0.804	1.500	0.783	

Degrees of freedom = 11

$^{*}t_{.05} = 1.796$

$^{**}t_{.025} = 2.201$

$^{***}t_{.01} = 2.718$

(2) $P_{AAYY} > P_{LAYY}$

(3) $P_{AANN} \overset{\text{(assumed)}}{\geq} P_{LANN} > P_{ABNN}$

(4) $P_{AAYN} > P_{ABYN}$

(5) $P_{ABNN} > P_{ABYN}$

(6) $P_{AANN} \overset{\text{(assumed)}}{\geq} P_{LANN} > P_{AAYN}$

(7) $P_{AAYY} > P_{AAYN}$

The left hand inequality of (1) and (2) support the idea that public price announcements decrease competition. However, if such advertisements are unmonitered by competitors, slight price decreases may occur as suggested by the right hand of (1), (3), and (4). The results shown in (5) and (6) suggest a negative effect of the most favored nation clause when taken alone contrary to the information theory argued by the FTC. A positive effect on prices caused by advance notification is suggested by (7). These inequalities together with the fact that the highest prices occurred with (AAYY) indicate the possibility that the effects of practices may be highly interrelated and nonlinear. Examination of this possibility led to the following conclusion.

Conclusion 5. The effects of the practices are not additive and are

therefore interactive.

A model which assumed an additive relationship among the practices was rejected at the .01 level (F-test) in favor of a model which assumed the existence of interaction terms.[17] Thus any analysis of the effects of individual practices alone may not be a reliable indicator of how the practices function as a group.

The result regarding most favored nation and/or Robinson Patman type behavior is particularly interesting. We conjecture that one key to understanding the influence of this practice is the structure of the demand side of the market. Small buyers pay higher prices. We conjecture that if small buyers constitute a large fraction of the market volume, prices with a most favored nation clause will be higher. Conversely, if the bulk of the market volume is from large buyers, the effect of the practice will be to lower prices.

D. Results: Volume and Efficiency

Data on volume, price variance and efficiency are shown in Table 7. Note that volume for the more competitive regimes (N-NN, ABNN, ABYN) tends to be greater than when the market practices are in effect (AAYY and LAYY). In fact, of the eight cases in the former group, five exceed all seven observations in the latter, two are tied with the maximal volume under (LAYY) and only one is less than the maximum (by one unit). As the differences are by and large not great, we shall not attempt a quantitative analysis. Volume tends to be

TABLE 7

SUMMARY DATA

	Experiment	Quantities(vol.) for Periods				Efficiencies for Periods				Price Variances for Periods				
		5	8	10	Last	5	8	10	Last	1	5	8	10	Last
N-NN	1	15	14	16	16	1.00	0.94	1.00	1.00	1188.7	656.0	137.3	65.2	231.3
	2	15	15	17	17	0.99	0.90	1.00	1.00	1460.4	135.4	104.2	91.0	31.7
	3	18	17	17	16	0.92	0.85	0.85	0.83	346.9	34.4	19.4	31.8	11.9
	9	16	15*	-	15*	0.91	0.92	-	0.92*	831.1	271.4	58.2	-	58.2
ABNN	6	18	18	18	18	1.00	1.00	1.00	1.00	81.2	3.0	3.0	2.8	3.9
	7	17	-	-	17	1.00	-	-	1.00	11.4	10.0	-	-	12.4
	8	18	18	18	18	1.00	1.00	1.00	1.00	13.2	12.6	11.9	9.6	2.5
ABYN	5	18	18	18*	18*	1.00	0.94	0.87	0.87	580.6	19.4	40.0	23.9*	23.9*
LANN	11	16	-	-	16	1.00	-	-	1.00	3.6	22.1	-	-	3.0
AAYN	5	18	-	-	18	0.94	-	-	0.87	45.6	1.1	-	-	75.0
	10	17	16	12	12*	1.00	1.00	0.82*	0.82*	787.2	18.9	54.2	5.7*	5.7*
LAYY	6	18	-	-	16	1.00	-	-	1.00	0.1	0.0	-	-	2.1
	7	15	16	16	16	0.97	1.00	1.00	1.00	333.9	27.8	0.3	0.2	0.2
	8	15	12*	-	12*	0.97	0.91*	-	0.91*	44.5	0.3	1.6*	-	1.6*
	9	9	14	-	14	0.67	0.99	-	0.98	22.5	6.8	10.4	-	3.9
	10	15	16	16	16	0.97	1.00	1.00	1.00	66.5	5.5	3.0	4.3	4.3
	11	15	16	-	16	1.00	1.00	-	1.00	80.7	0.3	0.9	-	2.2
AAYY	4	13	13	13	14	0.96	0.83	0.83	0.85	0.0	0.0	0.0	0.0	0.0

* Denotes duplication.

higher in the a priori more competitive regimes and the probability of such an extreme occurrence by chance (in terms of ranks) is less than five percent.

The efficiencies tend to be high and there is no general tendency for efficiency to be systematically high or low in the two types of regimes. Thus, possibly contrary to expectations, at least in the markets the market practices do not appear to lower efficiency systematically. Prices under the practices did not get sufficiently higher than the competitive equilibrium to substantially affect efficiency. This result is possibly related to the ''lumpy'' demand.

Finally, we comment on the within period price variances. Two results appear noteworthy. First, there is a general tendency for variances to decline over time. Second, and of more substantive interest, there is substantially more price variability without the market practices. In fact there are a number of periods of (AAYY) and (LAYY) when all transactions take place at the same price. This never occurs under (N-NN), (ABNN), or (ABYN).

CONCLUSIONS

The circumstances of the Ethyl case provide an interesting context in which to explore the role that market practices play in the oligopolistic price formation process. The central issue for this study is whether or not market practices of the sort used in the lead-based antiknock compound industry can have an influence over and above industrial structure.

The behavior of the simple markets studied here, with economic

parameters as stipulated for the lead-based antiknock compound industry, depends significantly upon the existence ot such practices. Market structure alone will not necessarily account for all supracompetitive prices and profits. Without the practices prices are near but above the competitive equilibrium and with all practices prices are significantly higher and are essentially midway between the Cournot equilibrium and the competitive equilibrium. This result supports a presumption that facilitating practices and not industrial concentration per se provide a vehicle for explaining industrial performance. Both variables are important.

The results of these experiments are consistent with other experimental findings. The behavior of the no-practice (telephone) markets are consistent with the original work of Hong and Plott (forthcoming) who discovered a tendency for such markets to converge near the competitive equilibrium. Aspects of the practices are similar to those of posted prices which are known to have an upward influence on prices (Plott and Smith 1978; Hong and Plott forthcoming; Smith 1981). In this context the results are also consistent with those of Stoecker (1980) in the sense that they demonstrate that conspiracy is not necessary for markets to diverge from competitive equilibrium. Thus, the conclusions advanced here can be seen as part of a more general pattern of results.

These results suggest a more extensive investigation of the interrelationships among practices and the detail of the individual strategies they evoke. The FTC advanced such an extension of theory

utilizing a hypothesis that information about a competitor's actions is the key variable. But, the data indicate an incompleteness of that particular theory as follows: (i) a type of joint maximization model which can be deduced from the theory received little or no support from the data, and (ii) one practice which appears to increase information about a competitor's actions resulted in lower prices. This is not to say that the FTC theory is without merit since many of the other qualitative results are in accord with the theory. Furthermore, the central role of information in oligopolistic markets has received substantial support from the experimental work of Fouraker and Siegel (1963).

The most difficult and important questions are related to the relevance of this study to the Ethyl case. Have similar practices led to higher prices in the lead-based, antiknock compound industry? Experiments alone cannot answer that question. In fact, because the industry is so complicated, experiments with the industry itself would not answer the question with certainty. It is clear from the experimental work, however, that in developing a method for measuring the effects of the practices, extreme care must be exercised in choosing the background set of practices against which the measurements are to be made. One cannot simply assume, for example, that the prices will be near the Cournot equilibrium in the ''absence'' of practices because some types of practices induce near competitive equilibrium behavior. Furthermore, in assessing the effects of all practices one cannot rely on generating an overall assessment by

examining the influence of one practice at a time. The general conclusion is that practices analogous to those of the industry resulted in the highest prices of all the treatments we studied. Naturally questions regarding the bases of the analogy with the industry will arise. For example, some might feel that additional variables should be controlled or added in order to obtain an appropriate analogy. Such questions can be answered by additional experimentation with other practices and parameters.

The Ethyl case itself has a closely related dimension which these experimental markets do not address. Practices are endogenous to the operations of naturally occurring markets, while practices in the experimental markets were fixed and imposed. If the results of the experimental markets are indeed suggestive of the influence of the practices in the antiknock compounds markets, then sellers have an incentive to invent, design, and promulgate functionally equivalent practices. Interestingly enough, acceptance of such practices may be a Nash response by buyers even though collective acceptance is to their collective disadvantage. High concentration ratios may provide a set of conditions sufficient for this type of institutional evolution to occur and regardless of the decision of the Commission, if enforced by the court, the respondents may successfully develop alternative practices. The experiments presented here do not address this important question.

APPENDIX

INSTRUCTIONS

General

This is an experiment in the economics of market decisionmaking. Various governmental agencies have provided funds for this research. The instructions are simple and if you follow them carefully and make good decisions you might earn a considerable amount of money which will be paid to you after the experiment.

In this experiment we are going to simulate a market in which some of you will be buyers and some of you will be sellers in a sequence of market trading periods. For each period you will be given an envelope labeled Buyer or Seller, which describes the value to you of any decisions you might make during that period. An envelope for a given period is to be opened just before the beginning of that period. You are not to reveal this information to anyone. It is your own private information. A blank sample is attached here as page 4.

Specific Instructions to Buyers

During each market period you are free to purchase from any seller or sellers as many units as you might want. Study the form on page 4. For the first unit that you buy during a trading period you will receive the amount listed in row (1) marked 1st redemption value; if you buy a second unit you will receive the additional amount listed in row (5) marked 2nd unit redemption value; etc. The profits from each purchase (which are yours to keep) are computed by taking the difference between the redemption value and purchase price of the unit bought. Under no conditions may you buy a unit for a price which exceeds the redemption value. In addition to this profit you will receive a 5 cent commission for each purchase. That is,

[your earnings = (redemption value) - (purchase price) + (.05 commission)].

Suppose for example that you buy two units and that your redemption value for the first unit is $200 and for the second unit is $180. If you pay $150 for your first unit and $160 for the second unit, your earnings are:

$ earnings from 1st = 200 - 150 + .05 = 50.05

$ earnings from 2nd = 180 - 160 + .05 = 20.05

Total $ earnings = 50.05 + 20.05 = 70.10

The blanks on the table will help you record your profits. The time of purchase, seller number, and the purchase price of the first unit you buy during the first period should be recorded on row (2). You should then record the profits on this purchase as directed on rows

(3) and (4). At the end of the period record the total of profits and commissions on the last row (17) on the page. Subsequent periods should be recorded similarly.

Specific Instructions to Sellers

During each market period you are free to sell to any buyer or buyers as many units as you might want. Study the sample form. The first unit that you sell during a trading period you obtain at a cost of the amount listed in row (2) marked cost of 1st unit; if you sell a second unit, you incur the cost listed in the row (6) marked cost of the 2nd unit; etc. The profits from each sale (which are yours to keep) are computed by taking the difference between the price at which you sold the unit and the cost of the unit. Under no conditions may you sell a unit at a price below the cost of the unit. In addition to this profit you will receive a 5 cent commission for each sale. That is,

[your earnings = (sale price of unit) - (cost of unit) + (.05 commission)].

Your total profits and commissions for a trading period, which are yours to keep, are computed by adding up the profit and commissions on sales made during the trading period.

Suppose for example your cost of the 1st unit is $140 and your cost of the second unit is $160. For illustrative purposes we will consider only a two-unit case. If you sell the first unit at $200 and the second unit at $190, your earnings are:

$ earnings from 1st = 200 - 140 + .05 = 60.05

$ earnings from 2nd = 190 - 160 + .05 = 30.05

Total $ earnings = 60.05 + 30.05 = 90.10

The blanks on the table will help you record your profits. The time of sale, buyer number, and the sale price of the first unit you sell during the 1st period should be recorded on row (1). You should then record the profits on this sale as directed on rows (3) and (4). At the end of the period record the total of profits and commissions on the last row (17) on the page. Subsequent periods should be recorded similarly.

Market Organization

The market in this commodity is organized as follows. We open the market for a trading period (a trading "day"). The period lasts for ____ minutes. Any buyer (seller) is free to telephone any seller (buyer) at any time during the period and place an order for one unit to be delivered at the end of the period. The price will be at the published price of the seller. [Note that contracts are only between buyers and sellers.] Each party is to say to the other the following: (price), (the other trader), (time). An order is placed only after both parties have made the above statement. All orders are for single units.

After an order is placed, the buyer and seller will record the time of the order and the published price on their record sheets. These should be recorded as demonstrated.

Final Observations

1. Each individual has a large folder. All papers, instructions, records, etc. should be put into this folder. Leave the folder with us before leaving tonight. Take nothing home with you.

2. We are able to advise you a little on making money. First you should remember that pennies add up. Over many trades and a long period of time very small amounts earned on individual trades can add up to a great deal of money. Secondly, you should not expect your earnings to be steady. You will have some good periods and some bad periods. During bad times try not to become frustrated. Just stay in there and keep trying and earn what you can. It all adds up in the end.

Some people rush to trade. Others find it advantageous to "shop" or spread their trading over the period. We are unaware of any particular "best" strategies and suggest that you adapt accordingly.

The record forms sometimes lead people to think in terms of "markup" and "markdown" strategies. While we see no general problems here, they can lead to occasional mistakes in computing the returns from decisions.

3. Under no circumstances may you mention anything about activities which might involve you and other participants after the experiment (i.e., no physical threats, deals to split up afterwards or leading questions).

4. Each individual will be paid in private. Your earnings are strictly your own business.

Description of Market and Behavior

There are four sellers (A, B, I, O). From previous market behavior it appears that demand is inelastic (price changes do not substantially affect overall market volume) and prices have varied over a wide range. Sellers A and B have relatively large capacity, while I and O are smaller. There is also likely to be substantial excess capacity.

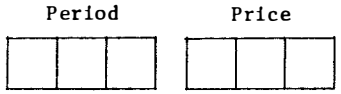
Prices

Sellers A and B advertise prices by entering the price on the keyboard in the seller's office. These will be announced immediately through the public display. Sellers I and O operate telephone contracts with individually agreed upon prices.

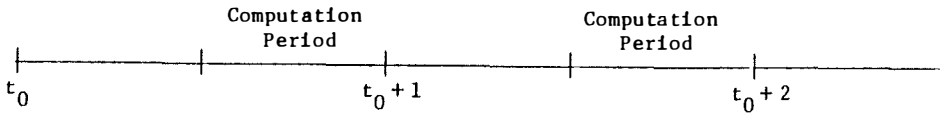
For A and B

1. Price increases must be announced one full period prior to the period in which the price increase is to be effective.
2. Price decreases are effective immediately.
3. No discounts from advertised prices are permissible.

Display



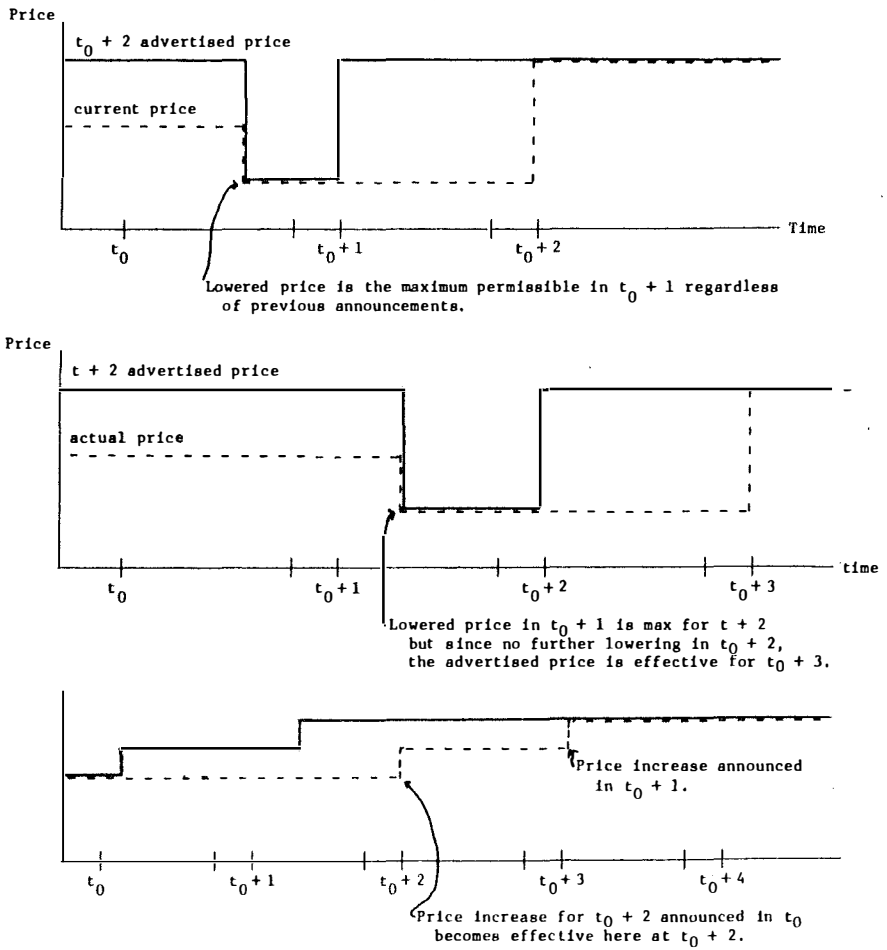
For A and B



†Price increases in $t_0 + 2$ must be made before here (last minute changes will result in an extension of the $t_0 + 1$ open).

If price is reduced in $t_0 + 1$ this reduced price is the highest (s)he can charge in $t_0 + 2$.

EXAMPLES

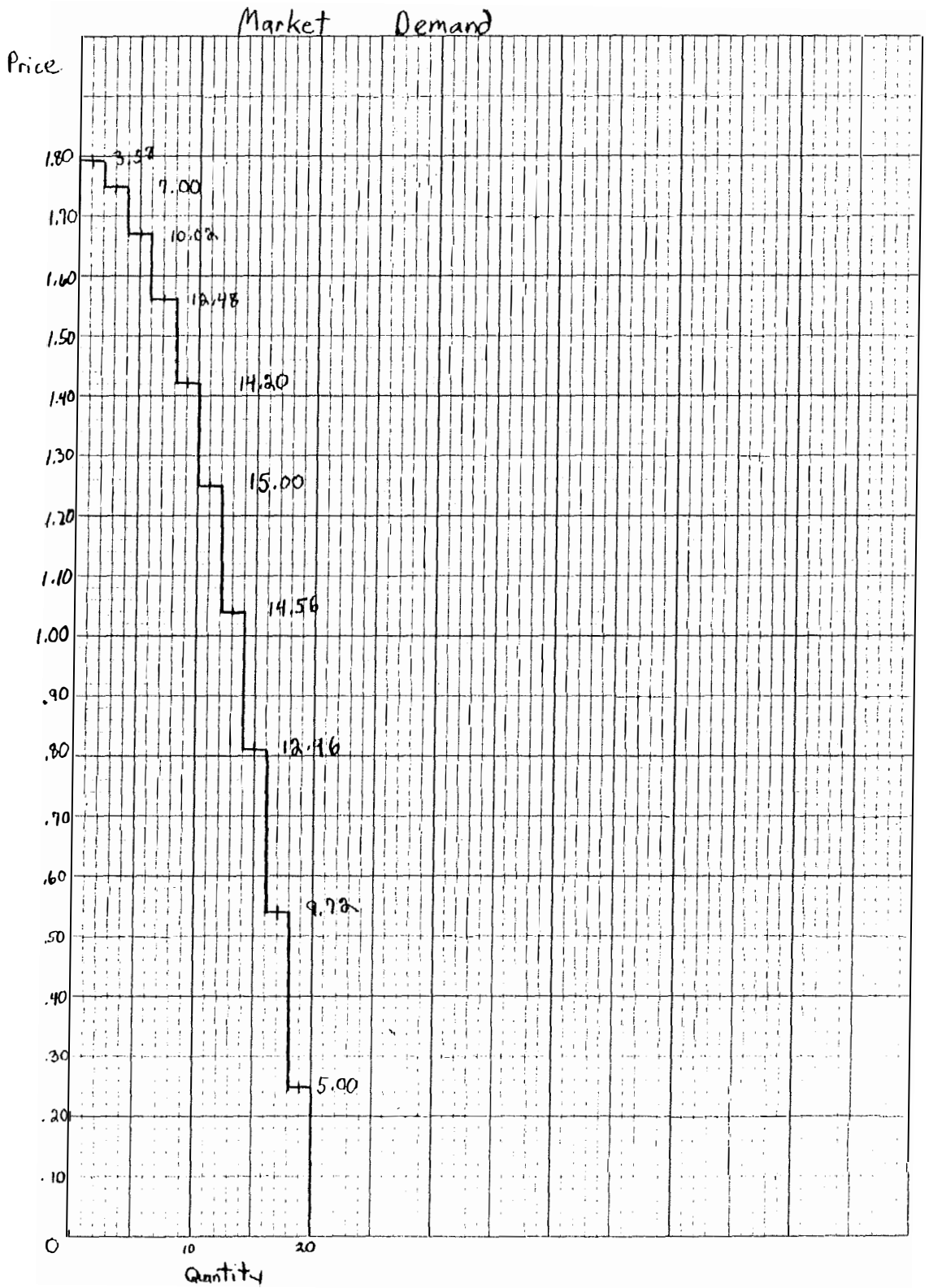


APPROXIMATE PRICE/VOLUME RELATIONSHIPS

The attached chart provides a model of the relationship between price and total market sales volume. Choose any price on the vertical axis and move your finger horizontally to the curve. The distance moved horizontally to the curve indicates the approximate volume at that price. As can be seen, price decreases beyond a certain point result in very small increases in total market volume.

The numbers distributed along the curve reflect the total dollar volume of sales for all sellers together at each price.

Costs of sellers have a similar structure but they are not identical. Considerable capacity is available at costs in the mid fifty-cent range, especially for A and B. In these ranges sellers could easily supply more units than the buyers would want (as indicated by the volume on the attached chart).


Market Demand
Price
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
.90
.80
.70
.60
.50
.40
.30
.20
.10
0
10
20
Quantity
3.52
7.00
10.08
12.48
14.20
15.00
14.56
12.96
9.72
5.00

FOOTNOTES

* Professor Plott has served as an FTC Bureau of Competition consultant on the Ethyl case. This research was stimulated by problems which surfaced in that context. Some initial experimental work was financed by the FTC. General funding by the National Science Foundation and the Caltech Program of Enterprise and Public Policy is gratefully acknowledged. We also wish to thank James Angel who was the senior research assistant for the project.

1. Ethyl Corporation, E.I. du Pont de Nemours and Company, PPG Corporation and Nalco Chemical Corporation, Docket no. 9128. Federal Trade Commission.

2. For a model of the influence of the speed of the detection of price changes see George J. Stigler, ''A Theory of Oligopoly,'' Journal of Political Economy 72 (February 1964):44-61.

3. The produot is homogeneous so small price differences can precipitate large volume changes. Furthermore, some suppliers included ''meet or release'' clauses in contracts which guaranteed that the supplier would meet the lowest price in the market or release the buyer from contractual obligations.

4. For a summary of other conditions and practices which are thought to have this effect see Scherer (1971, chapters 6 and 7).

5. See Smith (1976) and Plott (1979).

6. The individual would ask the price and then ask if if were the best price. If the price were twice or more what had been charged by other sellers, the passive buyer would not purchase. If the quoted price were anything less, a purchase would be made.

7. For some of the experiments sellers were named A, B, I, O because the letters B, C, and D sound similar and caused some time delays as a result.

8. One firm in the industry, Nalco, may have had a larger capacity, relative to other firms, than the figure used here. Complaint counsel's ''Proposed Finding of Facts, Supporting Memorandum, Conclusions of Law and Order,'' pp. 36-38.

9. The relative capacity of one small supplier in the industry (Nalco) is probably larger than its possible counterpart in the laboratory market.

10. No sessions of (AANN) were conducted. During the course ot experimentation it became increasingly clear that the two small suppliers had little market impact so this treatment was given a low priority.

11. A seller who wished to make a price announcement did so by entering a period number in the display. A public signal would then be made by the experimenter which alerted all participants

that a price announcement was to be made for the period entered on the display. All participants would then check the receiver units. After a brief wait, the new price for the announced period would be entered.

12. A total of twenty-four experiments were conducted. The first eight were considered as pilots in which many of the system bugs were eliminated. Several of the twenty-four were conducted prior to the construction of the price signaling device discussed above and all were discarded because of various problems relating to procedures, records, mistakes, etc. Two more experiments were eliminated, one because of a rule infraction involving a binding commitment to a future contract, and a second because it was conducted in a different facility where telephone conversations could be overheard by other buyers and sellers. The latter problem was discovered only after a subject called it to our attention near the end of the experiment.

13. The average prices for each period are taken as the dependent variable for the analysis of variance and they were not weighted to reflect differences in sample size (which for most treatments were small) as the volume or number of transactions is endogenous to the system.

14. Under the null hypothesis of no treatment effect, the distributions of the prices should be the same. If the alternative hypothesis includes change in scale as well as location, the Wilcoxin test, while giving the correct significance levels may not be very powerful. We also computed the statistic T suggested by Lepage (1971, 1973) for this class of alternatives with the following results. (N-NN) versus (LAYY): fourth period, approximate significance level .1; eighth period, .02; tenth period, not significant; last period, significance level between .1 and .2. (ABNN) and (N-NN) versus (LAYY) and (AAYY): fourth period, approximately .05; eighth period, aignificance level more extreme than .01; tenth period, not significant; and last period, significance level between .01 and .02.

15. A more extensive examination of this proposition should include as a hypothesis that the shape of the supply curve may be important.

16. See Scherer (1970, pp. 206-208) for a discussion of how lumpy demand makes price coordination difficult.

17. Consider the following ANOVA model:

$p = \alpha NNN + \beta A + \gamma P + \delta D + \varepsilon AA +$ interaction terms among A, P, D, AA, where

N-NN = 1 if no practices allowed; 0 otherwise.

A = 1 if advertising is allowed; 0 otherwise.

AA = 1 if advertising is available to all; 0 otherwise.

P = 1 if posted prices; 0 otherwise.

D = 1 if no discounts allowed; 0 otherwise.

$\bar{p}$ = average prices.

The test of the hypothesis that the coefficients of the interaction terms are all zero is rejected in favor of the more general model. Since the design used only seven cells, one cannot estimate the coefficients of the interaction terms, though one can compute the sum of squared residuals for that model which is all that is required for the F-test. In fact, this is just the figure shown in Table 2 for the seven variable model.

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